"SYNTHESIS AND CHARACTERISATION OF TRANSITION METAL OXIDE NANOPARTICLES FOR CATALYTICAL APPLICATIONS"

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1. Title

SYNTHESIS AND CHARACTERISATION OF TRANSITION METAL OXIDE NANOPARTICLES FOR CATALYTICAL APPLICATIONS

2. Aims of the study

The aim of the study is to synthesize metal oxide nanoparticles by using simple, cost-effective, and eco-friendly methods with readily available metal salt as a precursor. The prime focus of researchers is on the synthesis, characterization, and applications of transition metal oxide nanoparticles. The resultant metal oxide nanoparticles will be characterized by using various sophisticated techniques and further investigated for their utility as a catalyst for the photodegradation of harmful organic dyes, the catalyst for organic transformations, and anti-microbial activity.

3. Objectives of the study

1. To synthesize metal oxide nanoparticles with desirable size, morphology, crystallinity, and phase composition by using simple, inexpensive, eco-friendly methods.
2. To control size and shape by using various preparation methods, precursor concentrations, and capping agents.
3. To characterize synthesized metal oxides by using sophisticated techniques like XRD (for structural determination, lattice parameter, phase purity, crystallinity, particle size, etc) Scanning Electron Microscopy, and Transmission Electron Microscopy (for surface morphology to predict the size and shape of individual one), UV-Visible NIR Spectrophotometry (for determination of band gap(s), EDAX (for composition determination).
4. To study the influence of support on catalytic activity and selectivity for a selected catalyst to obtain the best photocatalyst for photocatalytic degradation of organic dyes, pesticides, surfactants, and industrial effluents.
5. To study the effect of loading (concentration) of active catalyst components as well as the catalyst dilution on activity and selectivity.
6. To evaluate performance in photocatalytic degradation with respect to various parameters such as influence of catalyst loading, pH, scavengers, time, etc.

7. To evaluate the antimicrobial activity of metal oxide nanoparticles against different microorganisms.
8. To study the catalytic activity of metal oxide nanoparticles in organic transformations.

4. Study Background (Literature Review) and significance of the study

Nanotechnology is a fast-emerging technology of the future; it is one of the most important and applicable technologies and a key factor in the future global market. Nanomaterials are considered to be a keystone of Nanoscience and Nanotechnology owing to their superior or entirely new properties with respect to the analogous bulk materials. In recent years, metal and mixed metal oxide nanoparticles are receiving more attention in a large variety of applications metal oxide nanoparticles are a key constituent in drug delivery [1], semiconductors [2], fuel cells [3], and catalysts [4-6]. Heterogeneous photocatalysis has proved to be an efficient tool for degrading aquatic dye contaminants. It uses UV and sunlight in the presence of a semiconductor photocatalyst to accelerate the remediation of environmental contaminants and the destruction of highly toxic molecules [7]. Several metal and metal oxide nanoparticles, such as ZnO, TiO_2, CuO, SnO_2, ZrO_2, and WO_3 have been utilized as a heterogeneous photocatalyst to remove organic pollutants [8-13].

However, the rapid recombination of photogenerated electron-hole pairs and poor utilization of solar energy limits the photodegradation efficiency of dye. To conquer these limiting factors, several efforts are being made. It includes tailoring of particle size, morphology, surface area, crystal structure, use of mixed semiconductors, the deposition of noble metals and doping with elements (metals and non-metals), etc [14-18]. The main purpose of this modification is to bring the absorption band from UV to visible region, reduce the recombination of electron-hole pair and enhance the photocatalytic efficiency. Furthermore, metal oxide nanoparticles have received great attention for catalytic applications in organic synthesis with some anti-microbial activities [19- 21].

The present research will mainly focus on the synthesis and characterization of modified transition metal oxide nanoparticles using simple and efficient synthetic methods. The synthesized metal oxide nanoparticles will show photocatalytic activity towards the degradation of toxic dyes, and anti-microbial activity and can be useful in organic transformation.

5. National Status:-

Metal oxide nanoparticles have been synthesized by using simple, cost-effective, green methods such as chemical methods, sol-gel, thermal decomposition methods, etc. It is necessary to minimize the time, cost, and efforts of the synthesis of metal oxide nanoparticles. Currently, Deshmukh, and coworkers reported the selective synthesis of TiO_2 nanoparticles. It required a precursor, higher temperature, and more time for catalytic activity. There is the scope of modification in methodology by using other precursors [22]. Babar, et.al. reported the photocatalytic activity of metal oxide nanoparticles toward the degradation of organic dyes. This takes more time for the degradation of methyl orange (MO) [23]. Kite, et.al. reported photocatalytic activity and the photocatalytic degradation of toxic dyes on TiO_2 nanocrystals the efficiency of degradation in this work was observed at an acceptable level [24]. Kamraj and coworkers reported the biological activity of Tin oxide nanoparticles synthesized using plant extract in this work reaction mixture was heated the synthesized Tin oxide nanoparticles show a remarkable zone of inhibition for various microorganisms [25].

6. International status:

Synthesis and applications of transition metal oxide nanoparticles attracted huge attention worldwide. Recently, Sana Akir and researchers reported the eco-friendly synthesis of ZnO nanoparticles with different morphology and used as a photocatalyst in dye degradation [26]. Ismat Bibi et.al. reported the green and eco-friendly synthesis of cobalt oxide nanoparticles at ambient temperature and its remarkable applications in dye degradation. [27]. Sabina Nicolae and her group reported a selective catalytic oxidation reaction of p-xylene using Manganese-Iron mixed oxide nanoparticles. In this work Mn-Fe mixed metal oxide nanoparticles are synthesized at a higher temperature under autogenous pressure. These mixed metal oxide nanoparticles showed better catalytic performance because of their smaller crystalline size. [28]. Kanika et.al. reported the eco-friendly synthesis of zinc oxide nanoparticles by using *C. papaya* leaf extract for the synthesis of ZnO nanoparticles it takes more time to adjust pH 12. In this work, a remarkable zone of inhibition was observed for the various fungal species [29]. Ali Akbari et.al. reported a review on transition metal oxide nanoparticles as an efficient catalyst in oxidation reactions. This report depicts the significant utility of transition metal oxide catalysts in the oxidation of sulfides, alcohols, olefins, and alkanes towards the synthesis of a variety of organic

compounds such as sulfoxides, aldehydes, ketones, carboxylic acids, epoxides, and alcohols [30].

7. Study Hypothesis:

The transition metal oxide nanoparticles have a wide range of applications in the field of chemical and pharmaceutical industries such as photocatalytic degradation of organic dyes, pesticides, surfactants, and industrial effluents, catalytical properties for various organic transformations, as well as anti-microbial properties.

Focusing on the importance and current growing attention towards the simple and efficient methods for the synthesis of transition metal oxide nanoparticles we herein proposed to extend the work on the synthesis of transition metal oxide nanoparticles using readily available and cheaper metal salts as precursors. The resultant metal oxide nanoparticles will be characterized by using various sophisticated techniques such as UV, FTIR, SEM, TEM, BET, EDAX, ICP-AS, XPS, etc. The synthesized materials may be found to possess significant photocatalytic properties for the photodegradation of harmful organic dyes, catalytic applications for various organic transformations, and anti-microbial activity.

The electron band gap of metal oxide nanoparticles plays a vital role in the dye degradation process and organic transformation. Therefore, the main focus of the present study is to synthesize metal oxide nanoparticles with significant band gaps which will help to increase the dye degradation rate of hazardous dyes and organic transformation.

8. Study Rationale

The synthesized metal oxide nanoparticles expect magnificent outcomes related to dye degradation, antimicrobial activity, and organic synthesis.

9. Research Methodology

Synthesis of Metal oxide nanoparticles

In the present study, we will design simple methods for the synthesis of metal oxide nanoparticles. Further, the synthesis of the metal oxide nanoparticles will be carried out by a suitable identified method. The characterization of nanoparticles will be carried out by XRD for a structural determination as well as particle size and surface morphology by SEM and

TEM. The elemental composition of the nanoparticles will be characterized by EDAX and for a qualitative arrangement of nanoparticles; the UV-Visible and FTIR will be used.

The desired size and shape of metal oxide nanoparticles will be tested for degradation of some organic moiety such as dyes, pesticides, surfactants, and industrial effluents. The correlation between various physical properties of nanomaterials and photocatalytic performance will be of interest along with this experimentation. In a further study, synthesized metal oxide nanoparticles will be assessed in organic transformation and anti-microbial activity.

10. Statistical Plan:

Months	Plan of Research work
1 to 6	Literature review and Course work
7 to 24	Laboratory work and characterization
25 to30	Result analysis, research publications
31 to 36	Synopsis and thesis writing

11. Limitations of the Study

As per the literature precedents, the catalytic activity of metal oxide nanoparticles is poor due to the fast recombination rate of photogenerated electron-hole pairs, only utilization of UV light than the entire solar energy limits the photodegradation efficiency of dye. Recyclability results for the metal oxide nanoparticles after successive consecutive cycles show lower catalytic activity in photodegradation and in organic synthesis.

12. Expected Outcomes of Study

a. The synthesized metal oxide nanoparticles will give a size range between 1-100nm.
b. The hazardous dyes degradation by using metal oxide nanoparticles will show remarkable outcomes.
c. The significant anti-microbial activity by metal oxide nanoparticles.
d. Synthesis of organic molecules by using metal oxide nanoparticles as a heterogeneous catalyst.

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